BEYOND DEEP TECH

Balancing technological innovation and social innovation for exponential hope

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Thomas Holm, Leapfrog Projects Ab and Katri Kallio, VTT

VTT

TO THE READER

This white paper is the result of a collaboration between VTT and Leapfrog Projects in a *Futures* initiative during 2022. The aim of the *Futures* initiative is to explore and create knowledge about the deep issues that face our current and future societies - and consequently will affect VTT's future development in the long run. We do not look only at the obvious, visible issues, but dig deeper, beneath the surface, to understand what the underlying causes might be. We make suggestions on how we could learn from these issues collectively and change the course of action towards more desirable futures.

We have made our best effort to synthesize models from across disciplines and schools of thought, and we have tried to do so by sticking to *good faith communication*. We hope that the text would not be read as a critique, but as an exercise in synthesis and sensemaking, without which a coherent future strategy is impossible. In our writing, at times, we use examples and analogies that might feel abstract - we typically do so to emphasize that a principle or pattern is universal. We also try our best to reason from *first principles*, meaning breaking down concepts into their basic elements and then reassembling them from the ground up.

At times, we will discuss the potential risks related to emergent technology, rather than opportunities alone. This should not be read as pessimism or cynicism. Without hope, we would not make the effort to write this piece in the first place. Further, we believe there is immense value in clearly formulating what approaches are likely not going to work. Especially in a time where there is little agreement on what an adequate set of solutions might look like, and where we are so strongly incentivized to focus on opportunity, rather than risks - at every level of society.

We especially want to thank Maija Ojanen-Saloranta, Szymon Wiktorowicz and Ali Harlin as well as the VTT iBEX teams for their valuable contribution to the thinking behind this paper. That said, the thoughts and arguments presented in this white paper do not represent VTT as an organization, only the authors involved.

We warmly invite the reader to provide us with critical feedback as well as suggestions for complementary models that would make our map more representative of the territory.

INTRODUCTION

VTT's current strategy revolves around the concept of exponential hope. "Exponential" refers to the rapidly accelerating pace of technological development, while "hope" reflects the belief in technology's potential to bring about significant positive change in society, such as increased productivity and sustainability. Undoubtedly, technology is progressing at an exponential rate and holds immense potential for transformative benefits. From this standpoint, exponential hope appears to be a valid value proposition.

However, it remains uncertain whether such a trajectory is assured in the present global cultural and socio-economic context. The primary argument presented in this paper is that solely focusing on individual technological innovations, no matter how “deep”, is not sufficient for achieving long-lasting positive impacts on society. It is crucial to strike a balance between *technological innovation* and *social innovation*. Only through collaborative efforts can these two forces potentially possess the capacity to reshape the "rules of the game." We refer to this integrated approach as *systems innovation*. [1]

As a way forward, we argue the aim should increasingly be on *systems innovation* that aims to solve underlying structural issues that give rise to our problem-landscape.

This means going beyond the technosphere and placing attention on culture (the values and worldviews we hold), governance structures (our institutions, laws, and regulations) as well as markets (our incentive and coordination structures).

The first part of the paper argues why neither focusing on technological innovation alone or social innovation alone are adequate theories of change.

The second part of the paper discusses how these two “worlds” could be integrated and what this integration could mean at VTT. Here we share learnings from our ongoing integration efforts as part of the VTT iBEX (iBEX) program.

We go on to propose the further development of iBEX into a strategic “learning laboratory” for prototyping novel synergistic approaches, collaborative practices and capability building that are both futures-driven and complexity-informed. We suggest that the learnings could be systematically adapted by VTT outside of iBEX in the future. The white paper ends in a summary of learnings and propositions.

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[1] *The authors of this paper have not come across any research that supports the thesis that economic growth and energy/materials consumption can be significantly decoupled on a global level within any relevant timeframe, if at all. When considering the global balance sheet, some studies still estimate something like a 99-100% correlation between energy/materials consumption and economic growth (cf Janocovici 2011). We invite the readers of this paper to share alternative viewpoints and evidence on this highly consequential topic.*

PART 1: WHY DO WE NEED TO INTEGRATE TECHNOLOGICAL INNOVATION AND SOCIAL INNOVATION?

Technological innovation and social innovation represent different approaches and schools of thought to solving problems. Technological innovation refers to a new or improved product or process whose technological characteristics are significantly different from before. Social innovation, on the other hand, refers to innovation that aims to address the underlying structural causes of problems. While technological innovation has largely been dominated by an orientation towards natural sciences, social innovation has tended to lean more towards social sciences. Consequently, there seems to be significant differences between the two approaches in almost every dimension: From worldviews, ontology, epistemology, practices, and methodologies to skill sets. This means that achieving shared sensemaking between the two approaches is a challenging task. Yet, we argue, this is a task that we need to undertake.

WHY TECHNOLOGICAL INNOVATION NEEDS SOCIAL INNOVATION

Here we argue that developing technology in isolation from its context is often a bad idea. Just to be clear there are degrees to which this is true: E.g., Radiation measurement using photodiodes could be applicable for atmospheric sciences, material sciences, industrial processes development or quality management; a new algorithm, piece of code, mathematical model or a quantum computer might have endless applications. In addition, some technologies are probably more prone to less desirable reverse engineering or repurposing than others. The first section deals with lost opportunities of isolated innovation - while the second section deals with the risks of it.

Value is created in context

First, and perhaps most obvious, developing technology in isolation from the context into which it is to be embedded, is difficult from the perspective of product-market fit. Without a deep understanding of market needs, it is unlikely that the technology will adapt or scale. To know if there is a product-market fit, one needs to engage with customers.

For transformative innovation to take place, a mere focus on co-creating a product or service together with the potential customers is not enough. One needs to understand and actively aim to affect the broader cultural, regulatory and market contexts.

It is also the case that individual technologies do not create transformative change. Transformative change requires entire ecosystems of adjacent technologies. E.g., the internet alone was not impactful in isolation; it required the emergence of personal computers, user friendly software and hardware, satellite networks etc. to have the impact it had).

Further, it is worth noting that market demand does not necessarily equal social good. There seems to be a significant gap between what the market demands short-term and what is valuable for society (and the natural world) long-term. The debate about the adequateness of current economic models and governance structures is not within the scope of this paper, but we encourage readers to further explore these deep and consequential questions[2]. Many have argued that current market failures cannot be "fixed" by mere regulation or reactive public sector interventions.[3]

To summarize, we need to better understand the dynamics of value networks and the systemic set-up where value is created, and where it is destroyed. Above all, to create exponential hope, we need to identify which problems are meaningful to address in the first place.

Potential risks associated with developing technology in isolation

Looking back at the past centuries, technology has transformed almost every aspect of our lives. In the most obvious ways, vastly for the better.

Simultaneously, however, most of our global challenges can also be viewed as the cumulative negative consequences of the narrow and short-term application of technology itself within dominating socio-economic contexts. This is not to blame technology itself for our problems, just to say that most of our problems are indeed technology mediated. In addition, we can see that the problems that are caused by technological innovations cause far more consequential problems down the line. For example, the automobile was designed to solve the problem of horse husbandry in growing cities, which it did, yet it also ended up causing ubiquitous pollution and causing global warming; Chemical fertilizers and pesticides were designed to increase agricultural output, which they did, yet they also created planetary-boundary-scale chemical pollution, soil erosion, ocean dead zones and a myriad of health issues; tetraethyl lead was designed to solve engine knocking, which it did, yet it also caused ubiquitous harm to the environment and our health.

It is not unreasonable to argue that most technological innovations focus on solving symptoms rather than the underlying dynamics that give rise to our problem landscape. Solving problems in isolation is ineffective at best, and catastrophic or dystopic at worst. Our aim here is not to single out technology as the root of our problems (one might make similarly compelling arguments about the role of human nature or social conditioning, different incentive structures or the exponential increase in extracorporeal energy use etc.) but since we are talking to VTT it makes sense to focus on the role of technology.

Complicated vs. complex systems

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[2] *These considerations include questions like: How do we decouple both energy and material consumption from economic growth; how do we avoid the continued rise of natural market monopolies (like Amazon, Google, Facebook, Uber etc); how do we bind risks related to distributed access to increasingly potent technology without centralizing too much power?; How do we deal with increased global supply chain fragility? Etc.*

[3] *See e.g., M. Mazzucato, The Entrepreneurial State (2013), S. Michaux (Towards a Resource Balanced Economy, GTK) add more.*

One reason for this is that we historically have mistaken the complex for the complicated. [4] The living world (the biosphere and the sociosphere) is generally complex, while most of the technological innovation throughout history has been complicated. The biggest challenge of a complex system is that it is difficult (or rather impossible) to define its boundaries, due to its interconnected nature. To understand how impact happens in complex systems one needs to understand concepts like emergence, phase transitions, trophic cascades, exaptation, attractors etc. We cannot assume that an interconnected system can be improved by picking something apart, “solve” the parts in isolation and assume that the whole is going to be “solved”. This is important to understand, because what follows is that every time you intervene with a complex system there will be unintended consequences outside the target area. What can be done to a machine cannot be done in a complex adaptive system. Now, please take a moment to digest how profound the implications of this is in terms of the way we organize and coordinate human activity at every level of society, how we do long term planning and how we measure success - all the way down the the language we use.

Physical and psycho-social externalities

We refer to unintended consequences as externalities. In economics, an externality is an indirect cost or benefit to an uninvolved third party (or the commons) that arises as an effect of another party's activity. For example, a factory that pollutes the environment creates a cost to society (and the natural world), but those costs are not priced into the final good it produces. If we try to solve problems in isolation, we always cause externalities. These kinds of dynamics are ubiquitous on every level of organization and in every sector of human activity: human relationships, business strategy, government policy, development aid, activism and, yes, technological innovation.

We often tend to think of externalities as being unintended consequences on the physical world (e.g., in the form of atmospheric CO_2, biodiversity loss or toxicity) but externalities can also be psychological, social and cultural. A case in point would be Facebook with its attention hijacking algorithms that drive mental health issues, polarization and breakdown of democratic decision making. These kinds of impacts can be thought of as psycho-social externalities of technological innovation. The same way that a factory might pollute our physical ecology, social media might pollute our information ecology.

Our technologies shape every aspect of our lives

It is worth noting that it is not only information technologies that cause psycho-social externalities - any technological innovation can have these effects. If You walk in a forest with a basket or walk in a forest with a chainsaw, what you pay attention to is necessarily going to be different, and the things you pay attention to directly affects your perception of reality. Had you made the shirt you’re wearing from scratch, you would relate very differently to it than if it were ordered from an online store

[4] *One key characteristic of complex problems or systems have emergent properties and behavior (such as self-organization) that make them non-deterministic. Meaning they are not computational. Simultaneously technological systems can also be complex (e.g., the Internet). (Available.ncbi.nlm.nih.gov/pmc/articles/PMC2465602)*

together with 10 other items. That is to say, the technologies that we use always change how we relate to everything and what we value - and consequently how we behave. Yet we typically don't take this fact into consideration when we design our technologies or when we evaluate their impact. This itself, we argue, is a potentially existential problem.

Technology	**Anticipated impact**	**Psychological impacts**	**Societal impacts**	**Speed of diffusion**
The plow (ca 3000BC)	Maximizing caloric surplus (grains)	End of animism, rise of "man's dominion over nature", rise or patriarchy	Immense population growth, Private property ownership, Marriage as an institution, Monopolies of violence (armies, police)	Millenia
The printing press (15th century)	Universal dissemination of knowledge	Rise of the western enlightenment	End of feudalism, rise of liberal democracy	Centurie(s)
Social media (2000s)	Driving social connectivity at scale	Increased polarization, diminished sense-making, increased mental health issues[5]	Rise of natural market monopolies (through network dynamics), Possibly the end of representative democracy as we know it?	Decade(s)

Table 1: Technology codes human minds and behavior and shapes our social fabric at an increasingly rapid pace (examples for illustrative purposes)

As we see technologies have historically played a central role in creating new emergent societal paradigms. The printing press together with "social innovations" like the scientific method and the Heiggelian dialectic etc. led to what we now call *modernity*. It is key to understand that it was not technology alone - it was a co-evolution of technological and societal innovation that led to this emergence. Therefore, it is discerning to see that many of today's technological innovations are captured by the existing paradigm and end up having very different impacts than first intended. For example, the Internet was supposed to facilitate radically better collective sensemaking by making all the world's information available for everyone - instead, in many areas, it ended up creating natural market monopolies through network dynamics that lead to diminished sensemaking. Blockchain technology was supposed to enable non-fungibility and create transparency, decentralization, and massive social value, but mainly ended up driving Ponzi schemes and financial speculation around cryptocurrencies, etc.

A final critical point is that the use of technology is not always voluntary: an axial age tribe could not opt-out from using the plow, if they wanted to survive long term; a company cannot opt-out from using Facebook, Google or Amazon to market their products if they want to stay in business; a nurse cannot opt-out from using a particular EHR if she wants to keep her job, and; a teenager cannot (easily) opt-out from using a particular social media due to issues related to social belonging etc.

[5] *See e.g. The WSJ Facebook Files (https://www.wsj.com/articles/the-facebook-files-11631713039)*

To summarize, if we take the arguments above seriously, it changes the way we frame the entire problem landscape. Instead of seeing our global challenges as, say, 17 SDGs, we suddenly have the very way technology is developed at the heart of what needs to be “solved.” This is a fundamentally different perspective than seeing problems as social, ecological, or economic problems, and then seeing technology as a solution.

WHY SOCIAL INNOVATION NEEDS TECHNOLOGY?

Here we argue that social innovation without deep technological integration is an inadequate theory of change. In the first section we discuss how an integrated approach is needed to address the underlying causes to our global challenges. In the other section we discuss the relationship between technology and power dynamics.

Addressing underlying causes

Social innovation typically refers to the design and implementation of new solutions which ultimately aim to improve the welfare and wellbeing of individuals and communities.[6] Social innovations can also be defined as innovations that can fundamentally change the systems that created the problems in the first place (see Westley et al. 2015). The latter definition is very closely related to the definitions of systems change and systems innovation.
While the focus of these types of initiatives is typically on identifying underlying patterns, structures and mental models that make stronger leverage points for positive impact, the role of technology oftentimes seems underrepresented.

To give the reader a flavor of what these underlying causes might be, consider the following examples. We are all familiar with the notion of “first-to-market advantage” where individual actors race to innovate faster than the competition to achieve a competitive edge. This can be thought of as a positive example of healthy competition driving innovation, but it also has a dark side, where all actors are forced to overestimate opportunity, while underestimating risks. The underlying structure that needs to be addressed is the market incentive that makes it profitable to run market races that privatize potential gains, while socializing potential harm. Other examples would be *prisoner's dilemma* and *tragedy of the commons* -type phenomena where individual actors also do what is advantageous short-term, while running a race to the bottom long term: “if one fishery doesn’t overfish a particular part of the ocean, someone else will - and the fish will be gone either way” or “As a major nation state, you ramp up your nuclear arms capacity, because you cannot trust that the other nation doesn’t”. All these examples are caused by incentive structures that in turn encode patterns of human behavior at scale - oftentimes in ways that lead to short term narrow optimizing at the cost of what would be desirable for the whole long-term. These phenomena, among many others, can be held responsible for the cumulative externalities that drive all our global problems - and eventually need to be addressed. This should be the playground of systems innovation.

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[6] *https://www.oecd.org/regional/leed/social-innovation.htm, + Wesley (2015)*

Oftentimes, innovators with backgrounds in social sciences tend to underestimate the role of technology in addressing these types of issues, since at first glance, they seem to deal with phenomena like social structures or even human nature. However, technology always conditions human behavior and human psychology - and with exponential technology it does so at increasing speed.

As we have recognized, the negative second and third-order consequences of social media are far-reaching. At the same time, it is not hard to imagine what the same technology could accomplish if developed based on a different, more conscious set of design criteria, business models, regulatory frameworks, and ethical considerations.

We can also envision how our increased computational capacity, decentralized ledger, and satellite imaging technologies could offer ways to better address issues related to the *tragedy of the commons* on a global scale, such as illegal logging, fishing, and even nuclear arms races, by fostering "forced transparency" between actors.

For better or worse, technology will shape our future.

Technology confers power

Technology expands the impact of the choices we make: Going from stone-tipped arrows and bows to catapults to intercontinental ballistic missiles expands our capacity to impact the world. Exponential technology gives us vastly more power than any previous technology or power structure. Simultaneously, anyone who does not apply technology will simply not have any say in the future - they will just lose. This is not a value-loaded statement of how things should be, it is merely an assessment of how things seem to be.

Again, we can see that it has been the case throughout history that more technologically advanced societies have always been the ones who make it through. Similarly, the most technologically advanced companies have outcompeted the lower-tech ones.

PART 2: HOW DO WE INTEGRATE SOCIAL INNOVATION AND TECHNOLOGICAL INNOVATION?

Our main argument is that increased focus should be placed on what might be called systems innovation. Innovation that aims to solve underlying structural issues that give rise to the phenomena typically thought of as global sustainability challenges. And to do so by leveraging our emerging technological capabilities.

As we have previously mentioned, achieving this goal necessitates going beyond the confines of the technosphere and giving greater consideration to culture (the values and worldviews we uphold), governance structures (our institutions, laws, and regulations), as well as markets (our incentive and coordination mechanisms).

Recognizing the enormity of this task, we propose that the minimum action we can take is to gradually cultivate a heightened awareness of the broader context. Additionally, we strongly encourage active engagement in public dialogue, multidisciplinary research endeavors, and the direct advancement of technologies aimed at reshaping cultural norms and societal structures for the better.

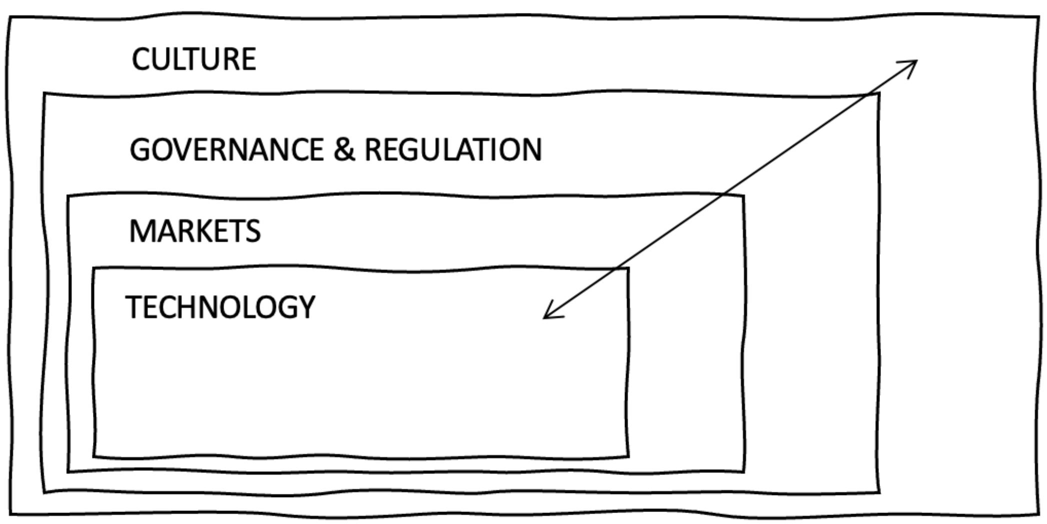

Table 2: The focus of systems innovation transcends the technosphere

This part deals with what the integration might look like and what it might require in terms of enabling structures, practices and capabilities in a Research and Technology Organization (RTO). Our case study is VTT and the iBEX Innovation program. We will start by describing our work around renewing the iBEX innovation program followed by a summary of learnings and recommendations.

CASE: REDESIGNING iBEX - WHAT HAS ALREADY BEEN DONE

Starting point

VTT iBEX is an annual early-stage innovation programme, which provides VTT's researchers with funding and support to address some of the most pressing global challenges. Traditionally, ten or so teams have had one year to identify and address a critical challenge by developing technologies that relate to one of the grand challenges.

While there is an ongoing effort to move from a technology-push approach towards a challenge-driven approach supported by VTT's strategy, we still observe that in practice the vast majority of applicants focus primarily on individual technological solutions. There have been notable difficulties in bridging the gap between the "problem" and the "solution". Arguably, our observation is that most applications are still strongly pushing technological solutions - instead of being truly challenge-driven.

What was done differently

From the very beginning our guiding question has been how do we move towards a more future-oriented and complexity-informed approach. Bearing this in mind, the aim of the renewed iBEX 2023 is to drive and support ambitious research and innovation openings that develop VTT's scientific and technological excellence and capacity building towards a more systemic approach - placing emphasis on teams' willingness to learn.

Noticing that most of the applicants from previous years have focused on innovations in the space of physical infrastructure, mostly coming from different fields of material sciences, we wanted to steer teams into thinking about societal issues as well. Meaning that we need to go beyond the technosphere and place increased attention also on deeper societal culture (the values and worldviews we hold), governance structures (our institutions, laws and regulations) as well as markets (our incentive and coordination structures).

We decided to work with internal and external experts on three vitally important themes: 1. *Future energy*, 2. *Future materials,* and 3. *Future society*. The most fundamental challenges and interconnections within each theme were presented to the applicants in May 2022 together with a set of orienting questions and case examples of more systemic approaches to innovation in each context. With these questions in mind, in the initial applications, teams were asked to describe a future vision, a transition pathway and an illustration of the first steps to be taken.

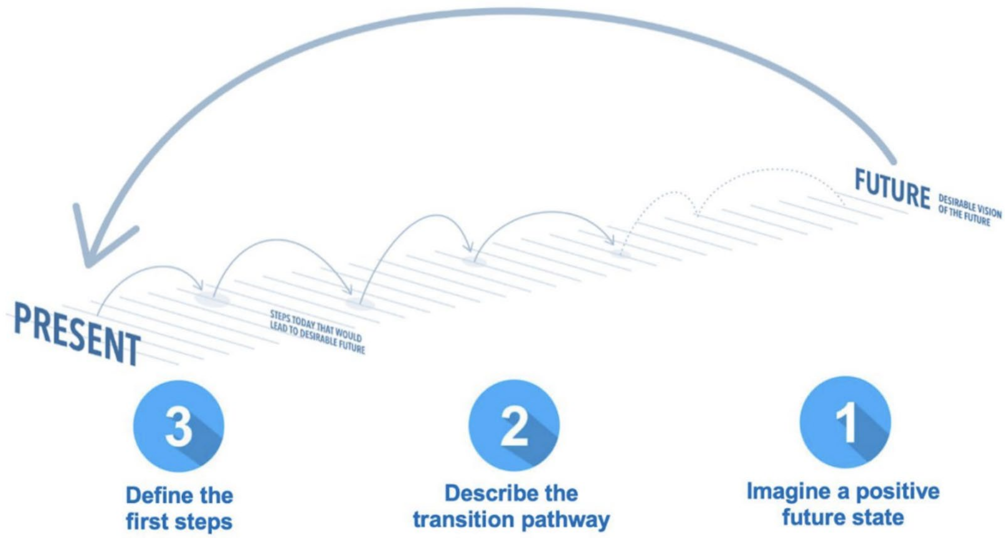

Figure 1: Structure for the initial proposals

The applicants were evaluated based on four criteria:

1. Level of scientific ambition
2. Level of transformational ambition: how much the proposal aims at challenging / changing the current system vs conserving it or aiming only at incremental change)
3. Level of systems-informedness: the starting point can be systemic or technological, but the aim is to maximize positive environmental, economic and societal impacts while minimizing harm
4. Level of anticipation: understanding the underlying causes to problems and dealing with potential externalities

19 applications were received that focused on Future materials (11), energy (7) and society (5). The "materials" and "energy" teams were primarily technology focused while the ones that addressed more systemic or societal challenges often lacked the technological component.

	Tech focus	Systems focus
Materials	10	1
Energy	4	3
Society	2	3

Table 3: Application by theme compared to technological vs. systems focus (Some applications covered several themes (e.g., both energy and society). In this table they have been counted to both themes and therefore X+Y+Z > 19)

A decision was made to extend the duration of the program from one year to two years and to limit the number of teams from approximately 10 to three. To achieve this, we consolidated separate applications around three themes that naturally emerged during the selection process. These themes are centered around closing the loop in three relevant contexts: the future circulation of sustainable materials, future closed-loop food systems, and future sustainable energy systems.

In practice, we made a deliberate decision to select the most desirable and feasible future visions and welcomed other applicants to contribute to these visions by enriching them with their own approaches. For each theme, we assigned an initial project lead who was chosen based on their systems-orientation. These project leads were responsible for guiding the initial visioning, organization, and coordination activities within their respective themes.

A so-called gallery walk was arranged where the chosen applicants would be presented with each other's visions, transition pathways and concrete proposals. The idea was to help teams identify potential synergies, as well as their unique role in the three chosen areas.

LEARNINGS AND RECOMMENDATIONS

In this section we summarize our learnings from working with the iBEX program and aim to give the reader an overview of what might be done differently if we are serious about addressing complexity.

LEARNING 1: THE NEED FOR A STRATEGIC LEARNING LAB FOR SYSTEMS INNOVATION

Facilitating innovations that aim to overcome existing constraints and have a transformative positive impact on society is challenging within current organizational structures. We argue for the necessity of specially designed spaces where transdisciplinary teams can create, test, and learn from prototypes that have the potential for transformative impact.

Dedicated innovation centers or "sandboxes" that provide intrapreneurial teams with greater freedom to experiment, while still holding them accountable to high standards are gaining popularity. Among other, this approach entails the development of new milestones tailored to more autonomous teams and providing metered funding that aligns with these milestones.

Rather than attempting to directly change individuals' mindsets, the focus of effective change initiatives should be on designing structures, goals, leadership, coordination practices, and enabling constraints that facilitate new types of interactions. Therefore, a safe space is needed to foster and encourage new interactions across disciplines.

CURRENT STATE (iBEX 2018-2022)	DESIRED DIRECTION: iBEX 2023 AND BEYOND
Setting goals and intentions	
(Deep) technological innovation	Balancing technological and social innovation
Measuring success	
Maximizing impact through achieving scale in the current paradigm	Maximizing impact through deep shifts in paradigms (transitions)
Nature of the problem	
Technological challenges (and focus on the physical infrastructure)	Systemic challenges (focus on physical infrastructure, markets, governance and culture)
Nature of the solution	
Individual technologies	Coordinated portfolios of technologies together with non-technological innovation
Target group	
Markets (customers)	Society (citizens/customers) (and the natural world)
Capabilities	
Deep skills in technology and natural sciences	T-shaped skills across technological, natural, social and systems/complexity sciences, perspective seeking
Coordination and decision-making	
Relatively centralized coordination and decision-making primarily based on outcomes-based, metrics.	Centralized coordination and distributed decision-making, primarily based on measurable heuristics.
Practices	
Analytical (reductionist) approaches, deductive reasoning, mechanistic language, artifacts and rules	Holistic approaches, abductive reasoning and learning, complexity-informed language, artifacts and heuristics

Table 3: Summary of the proposed direction of iBEX

Recommendation 1.1: Strengthen iBEX role as a strategic learning lab

We propose strengthening the role of iBEX as a sandbox for exploring, prototyping, and testing not only new innovations, but also new ways of organization, new practices and new ways of approaching learning. It is important to make sure the learning is multidimensional, and feedback-loops also feed back to the strategic decision making of the broader organization (i.e., strategic adaptation). This first recommendation can be seen as an enabling structure that supports all of our following recommendations.

LEARNING 2: INNOVATION NEEDS TO BE INCREASINGLY TRANSDISCIPLINARY

As we have argued throughout this white paper innovation needs to be done in a way that is more conscious about its impact in society. The perhaps most obvious response is to increase transdisciplinary capabilities in teams. We define transdisciplinary here as an approach that transcends disciplines, instead of just combining them in a "*you do that, and I do this-manne*r" that we might recognize from university teamwork exercises. The core inquiry is to reach higher order synthesis.

The first critical realization here is that there is a clear divide between the natural sciences and the humanities both within VTT and in broader society. In both camps, there are strong attitudes and critiques towards the opposing side. Simultaneously, it is clear from reading the iBEX applications that what the humanities lack in terms of technological understanding, the natural sciences lack in terms of socio-cultural systems understanding. Naturally, the natural vs social sciences divide is not the only divide that is important, there are higher resolution silos in place as well. Consequently, we propose that increased attention should be paid to integrating transdisciplinary collaboration between disciplines. To be clear, we are not arguing for getting rid of silos (this is probably neither desirable or even possible). Instead, we propose fostering informal networks and creating spaces to do action-based transdisciplinary learning that create links and interconnections between silos. This could be leveraged by motivating so-called T-shaped skills among all seniors in the company, from senior scientists and team leaders up to research professors and vice presidents. In addition, incentives for transdisciplinary research are worth considering at VTT.

A second critical realization is that even within our (multi-disciplinary) core iBEX team doing shared sensemaking is extremely difficult and time consuming. It quickly becomes obvious that we lack a shared language to discuss things like ontology (what is real) and epistemology (how do we know) - not to mention things like deep tech, systems change, transitions or transformative innovation. As we have discussed previously this difficulty stems from differences not only in skills and knowledge, but perhaps more importantly in life experiences, values and worldviews. We propose allocating sufficient time and resources to facilitate better shared sensemaking - as it clearly is upstream from good choice making. Critical capacities like *perspective seeking* should also be fostered across the organization. Understanding not only objective facts but also alternative arguments is perhaps equally important to achieve change.

A third critical realization is that there are currently few participatory decision-making practices in place when it comes to how we do innovation. Since we have established that technology directly shapes human psychologies, cultures and the social structures that govern them, the whole idea of developing technology in a way that excludes most of the population could be seen as morally dubious. It is easy to understand how information asymmetries between, say, scientists and the public have led to the current state. However, considering the broad societal and human impacts of technology together with the evolution in practices and technologies for inclusive decision-making we believe this needs to change, and that VTT should be at the forefront.

We have previously made the distinction between complicated (ordered) and complex systems, and we have argued that understanding this distinction is a minimum requirement to be effective in the world. As innovation is always contextual, it follows that what works in one context doesn't necessarily work in another.[7]

Recommendation 2.1: Enable transdisciplinary learning in context

Create space for action-oriented collaboration between disciplines in specific contexts (e.g., iBEX) using complex-informed and futures oriented practices

Recommendation 2.2: Build T-shaped skills and foster *perspective seeking* as a value

Increasing T-shaped skills among all seniors in the company, from senior scientists and team leaders up to research professors and vice presidents. In addition, critical sensemaking capacities like *perspective seeking* should be fostered across the organization. Understanding not only objective facts but also alternative arguments is perhaps equally important to achieve sustainable impact.

Recommendation 2.3: Increase inclusivity in innovation

Explore feasible tools and practices that address the lack of participation and inclusion in innovation and technology development (e.g., participatory design methods and tools, culture mapping etc.).

LEARNING 3: FROM PROBLEM SOLVING TO CAPACITY BUILDING

Our culture has an almost ubiquitous focus on first identifying specific challenges and then proposing solutions to narrowly defined challenges. While this "problem/solution" framing might seem intuitive - and surely is useful in many contexts, it's probably not the way to approach complexity. Instead, we argue for the need to develop capabilities that help us respond to interdependent problems that we cannot yet anticipate.

One could argue that most of the focus of organizational strategy, HR and change management is currently placed on building skills and capabilities at the individual level. Yet, change in organizations does not happen by trying to affect individual behavior, but rather through structural changes that create enabling constraints in the interactions between individuals and groups of individuals.

Instead of trying to affect the behavior of individuals with extrinsic rules and rewards, we should focus on affecting the interactions between individuals. Not only is this likely to be more effective, it also solves the ethical dilemma of imposing our own values and perspectives on others - and likely weakening their intrinsic motivation. In fact, the research is clear on this one: extrinsic tangible rewards undermine intrinsic motivation.

[7] *https://thecynefin.co/about-us/about-cynefin-framework/*

Throughout the project we have noticed that people tend to ask for very specific instructions for how to act: “Do you want me to do like this or like that?” This behavior seems to be deeply ingrained, for reasons that are not hard to understand considering how our educational system and modern workplaces are designed. Rules work well ordered systems, but not in complex or chaotic ones.

When faced with uncertainty heuristics (or rules of thumb) work better than rigid rules. As an example, the US Marines employ heuristics such as “Keep moving, seek high ground, stay in touch” for dealing with unexpected situations. Notice, that while this is not a rule, it is still measurable. It is also not an individual skill - it is a heuristic that improves interaction and coherence in teams. It is hard to imagine an effective innovation process that is constrained only by rigid boundaries and rules. Rather, the people should be encouraged to set their own target conditions and find their ways to navigate towards them. The OKR approach applied at VTT allows teams to set their own target states (*Objectives*) for the most important changes they want to see. *Key Results* are outcomes during the navigation that help to steer towards achieving these target states.

One starting point is to introduce new evaluation frameworks that cannot be as easily “gamed” as, say, the SDGs. Ones that view technology development as part of the problem landscape - not only a solution.

As every model and framework is inherently reductionist (The map is never the territory!), we propose a set of guiding questions to better navigate the development of appropriate responses to our global problem landscape. These questions are not meant to replace external evaluation frameworks but can serve as guiding principles that teams can use as checklists.

Orienting questions	
Q1	What physical externalities might your solution result in, if it were successful? What is the process for factoring these externalities upfront?
Q2	What psycho-social externalities might your solution result in, if it were successful? What is the process for factoring these externalities upfront?
Q3	What are all the underlying causes of the problem and how are you addressing them? If you are not addressing the causes, what other effects will these causes still have?
Q4	Where are there systemic perverse incentives that would orient other actors to make your job of solving the problem more difficult? How would you address those perverse incentives?
Q5	How could you address transparency and accountability in the system to address perverse incentives?

Table 4: Examples of orienting questions for systems innovation

Recommendation 3.1: Shift the balance away from extrinsic "rewards" towards more intrinsic "rewards" wherever possible

In addition to existing (external) outcomes-based metrics (like publications, patents or spinoffs), we propose introducing new evaluation frameworks that are based on things like expansive learning, orienting questions and measurable heuristics.

Recommendation 3.2: Shift the balance away from a problem-solution mindset towards a capacity building / learning mind-set

In addition to thinking of impact in terms of discrete problem-solving exercises, we propose exploring new ways to build capacity that allow us to be more flexible in addressing future challenges that we have not yet identified. Instead of jumping to quick solutions we should think about frameworks of actions that are adequate for dealing with multiple interconnected challenges. This is a very different approach to innovation, that could significantly strengthen our capacity to deal with an evolving problem landscape, through increased resilience and antifragility.

LEARNING 4: THE DEVELOPMENT AND USE OF ANY TECHNOLOGY IS ALWAYS AN ETHICAL CHOICE

The dominating view is that technology is never either good or bad: You can use a hammer to build a house or to hit someone over the head with it. "This approach is called *technological orthodoxy*, and it views technology as neutral regarding human values… (and this view) must change if humanity is to survive in a world of ever-increasing technological presence and complexity."[8] As we have argued before, the technology that we use does shape our psychologies and values, and the use of this technology is often not optional.

This realization, together with many of the learnings above, point at the need to deepen the understanding of the role of technology in society. This need has been recognized in many leading universities (especially in the US), where students are provided with programs in Science, Technology and Society (STS). These programs typically provide two types of courses: Technical courses, where you learn and practice science or engineering, as well as courses where you study the social and historical context of science and technology. These latter courses engage students with critical aspects of how science and technology affect political-economics and culture, and *vice versa*.[9]

As a final point, we want to raise a word of caution about principles like "Do No Significant Harm (DNSH) or statements like "maximize impact while minimizing harm". This line of thought will always be vulnerable to the risks related to utilitarian ethics. Since there is always uncertainty (and the *unknown unknown* space keeps growing with increasing levels of complexity) applying utilitarian ethics to decision making must be done in caution, and in balance with virtue ethics. In a world, where both funders and customers are used to run utilitarian calculus, we cannot rid ourselves of these

[8] *https://consilienceproject.org/technology-is-not-values-neutral/*
[9] *https://sts.stanford.edu/about/what-study-sts*

concepts (and neither should we). But we can certainly consider this balance in designing our organizational culture and our internal incentives.

Recommendation 4.1: Increase internal awareness about the role of technology in society
Provide research and learning opportunities at every level of the organization around the topics of technology in society.

Recommendation 4.2: Take an active role in the emergent public discourse around the topic of ethics and exponential technology
Increase engagement in the emerging societal discussion about balancing the opportunities and potential negative impacts of exponential technology, when advanced within the current socio-economic context. One logical starting point is the context of research and innovation policy.

LEARNING 5: NEW COLLABORATIVE LEADERSHIP PRACTICES THAT SUPPORT EXPANSIVE LEARNING AND SYSTEMS INNOVATION

Learning has been emphasized as a key process of innovation. The role of leadership in the future should be to enable and foster collaborative learning in networks of actors. As we are dealing with systems, complexity, multiple perspectives, and sensemaking, the leadership itself will need to transform from individual solo acts to new collaborative leadership practices that support collaborative sensemaking, learning and innovation. Defining the purpose and setting the statements of intent needs to be brought where the sensemaking, learning and innovation takes place - in the case of VTT to the Challenge Focuses, the focus areas of the research and customer work. The teams need to have ownership on their goals. Commitment to these goals is built through dialogue and transparent exchange of information. Regular reflection of learnings and sensemaking supports navigation in changing operating environments.

Our proposal as a way forward is grounded in the theory of expansive learning, which describes how organizations can learn to renew their activity in a cyclical manner by perceiving current contradictions in their activity and by creating a new concept of activity to meet shortcomings in practice. We propose the theory of expansive learning is supplemented with user- and strategy-based innovation to enable its application for collaborative leadership and analysis of strategic learning experiments. Hence, we need to strengthen both the bottom-up and the top-down perspectives in learning and innovation.

Currently, we are working on formalizing a developmental impact evaluation framework called LIFE (Learning by Foresighting and Evaluating) for iBEX that offers teams and external stakeholders a process for evaluating projects (or prototypes), learning from them, and constructing new research questions and prototypes. The learning method opens the concept of “research impact” as a qualitative learning challenge, rather than an accountable target to be judged from the outside. It may be adopted as a continuous way of managing and renewing transdisciplinary research and innovation in an organization. It should also change the prevailing horizon and realize the objects and motives of activities in a wider context than was previously the case. This can be seen as an effective tool for enabling expansive learning.

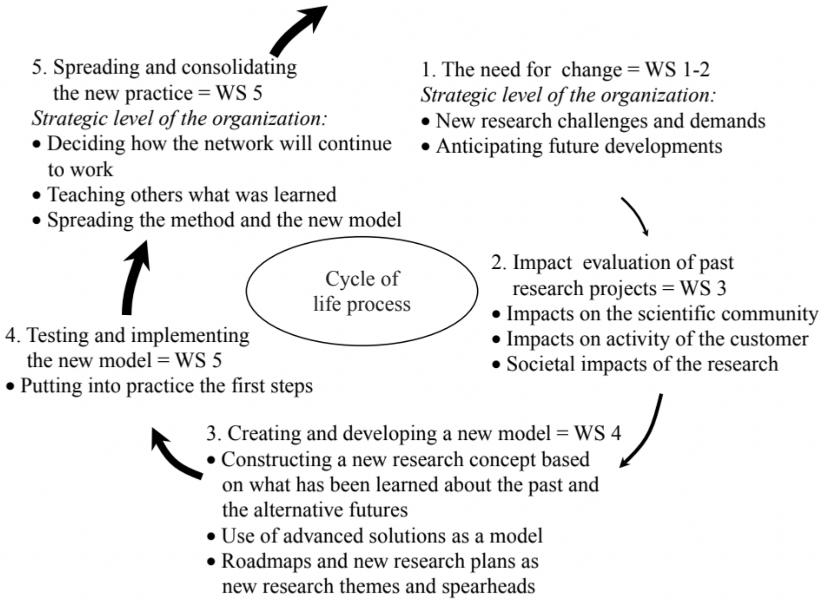

Figure 1: Initial evaluation framework for expansive learning and systems innovation in iBEX

It is worth noting that leading these types of learning processes in organizations have never been solo acts. There has always been a team of persons with complementary skills leading and facilitating the learning process.

Recommendation 5.1: Try out a novel co-leadership model for iBEX

Explore alternative ways of leading expansive learning that aims for integrating technological and social innovation. Considering that these two approaches to innovation stem from very different worldviews and scientific disciplines, we need strong leadership that recognizes the value of both worlds.

Recommendation 5.2: Develop new capacities and practices in systems, design, and future thinking as well as complexity sciences

Develop new capacities as part of iBEX 2023 by working together with the VTT design team and relevant external experts (e.g. methodologies from design and futures studies, complexity and systems sciences.)

Recommendation 5.3: Explore new funding opportunities

For all of this to be sustainable long term, we need to further explore new external funding opportunities regarding systems change and transformation. We propose working together with VTT International Affairs as well as experts from Business Units and Project Funding to systematically map opportunities related to the funding of transdisciplinary research, systems change and transformation initiatives.[10]

[10] *In the wake of the pandemic and the crisis in Ukraine, we a e can see that these topics are increasingly making their way into mainstream institutions such as the EU (e.g. the EU Field Guide: Managing Complexity, EIT Climate KIC, Deep Demonstrations, TransCap), OECD (e.g. Systemic Recovery), Vinnova (Navigating Food Transformations), several UN institutions (e.g. UNDP Portfolio Approach) among many others.*

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